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Systematic Review on Spices and Herbs Used in Food Industry

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Abstract

The narration of herbs and spices is as long as the narration of human beings. People have used these plants since ancient times. Edible spices and herbs serve many advantages in food products. Their primary advantages are to enhance flavor, aroma, texture, and color of food. Spices and herbs also provide secondary effects, such as preservative, nutritional, and health functions. Use of spices, their extracts or active components in different forms for controlling microbial growth or their toxin metabolites in food constitutes is an unconventional approach to chemical additives. The naturally occurring phenolic compounds (phenolic diterpenes, diphenolic diterpenes) in spices are effective against oxidative rancidity of fats and antimicrobial property. Phenolic compounds are the primary antioxidants present in spices and there is a linear relationship between the total phenolic content and the antioxidant properties of spices.

Keywords: Spices; Antioxidant; Antifungal; Sensory effect; Antibacterial

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Introduction

Spices are common food condiments, which have been used as flavoring, seasoning, and coloring agents and as preservatives all over the world since earliest times, particularly in India, China, and many other southeastern Asian countries [1]. Spices can be derived from bark, buds, flowers, fruits, leaves, rhizomes, roots, seeds, stigmas and stem or the intact plant tops of plant. Herb is used as a subset of spice and refers to dried leaves of aromatic plants [2]. Prevention of foods from microbial, chemical and physical deteriorations have been a vital concern in the food industry. In modern years, consumers are challenging for partial or complete substitution of chemical / synthetic preservatives due to their possible bad health effects (Roller, 1995). This reality has guide to an increasing awareness in developing more natural or friendly label on processed foods. Many spices have been considered to have remedial properties and give many valuable effects on health, such as antioxidant activity, digestive stimulant action, anti-inflammatory, antimicrobial, antimutagenic, anticarcinogenic potential [1].

Amongst the spices largely used for flavoring foods and at the same time have their antimicrobial potential are garlic, onion, nutmeg, mustard, black-pepper, thyme, oregano, rosemary, mint, basil, paprika, cassia, celery, ginger, coriander, cinnamon and cumin [3]; [4].

Spices, like vegetables, fruits, and remedial herbs, are also known to possess a variety of antioxidant effects and properties [1]. Phenolic compounds in spices and herbs are strongly associated with their antioxidant activity. The antioxidant effect of phenolic compounds is principally due to their redox properties and is the effects of various feasible mechanisms: free radical scavenging activity, conversion metal chelating activity, and/or singlet oxygen quenching capacity [1]. Spices is natural food condiments that have been use since ancient times to enhance the sensory quality of foods. Spices and herbs impart characteristic flavour, aroma, taste and colour to foods. Some spices, like fenugreek and ginger, can also modify the texture of food [5].

Sensory effects of Spices and herbs

Food condiments are strong smelling, sharp tasting plants frequently used to improve aroma, texture, and color. Common examples include mustard, nutmeg, ginger, garlic, coriander, locust bean [6].

Sensory effects of spices and herbs have been noted on appearance, color, odor, taste, texture and overall like [7]. Studied the quality of bread with added turmeric powder, turmeric essential oil and turmeric extracted residue at 0.10% and observed that the texture, appearance, taste and overall acceptability of bread containing turmeric residue had higher liking scores.

[8] Assayed the effects of *Aframomum danielli* and *Zingiber*

offcinale crude extract on the sensory quality of fried bean cake snacks. The result indicated that fried bean cake samples with both spices in different concentrations ranging from 0.2-1% were well acceptable by the panelists in terms of appearance, taste, texture, favour and overall quality.

[9] studied effect of oregano herb on dough rheology and bread quality and obtained bread with good baking, textural, nutritional and sensorial properties. Results of sensory analysis suggested that the addition of oregano in the bread had a positive response towards consumer acceptability. Overall acceptability score varied from 8.38 to 7.95 as compared to control (7.90). The bread incorporated with oregano at 2% level had higher acceptability than the control. Oregano also created a favorable taste of milk and its product. Increasing in density of oregano lead to favor, taste, essence and color of yoghurt as compared to control yoghurt that included 0% oregano [10].

Organoleptic overall satisfactoriness, taste, colour and texture of the fish products at 5% ginger concentration had the best reception and significantly different (P<0.05) when compared to the non treated control after 8 weeks of storage [12].

The highest flavor and improved texture was observed in black Adan instant rice formed by the addition of ginger (3%) after brewed in the process of soaking and cooking [14].

Incorporation of dried and powdered coriander leaf into wheat flour showed that the supplemented breads have in general, enhanced moisture retention capacity, slower staling rate, richer antioxidant content, better baking characteristics, and improved sensory properties in terms of color, texture, mouth feel, and flavor. Powder coriander leaf content between 3.0 and 5.0% (w/w) on wheat flour was found to be the optimum supplementation level offering the highest acceptability of the fortified bread [11].

Antifungal Activities of Spice and Herb

The growth of usually occurring filamentous fungi in foods may result in production of toxin metabolites (aflatoxins, deoxynivalenol, fumonisins, ochratoxin) known as mycotoxins, which can cause a variety of disease in humans, from allergic responses to immunosuppressant and cancer. Contaminated and poisoning of food by fungi is a major problem, mainly in developing countries. *Aspergillus, Fusarium* and *Penicillium* species are the primarily important fungi causing spoilage of foodstuff [13].

Environmentally associate plant extract agents have shown to be great potential as an alternative to synthetic fungicides [15].

[12] studied the antifungal property of ginger solution (2.5, 5, 7.5 and 10 %) on the smoked dried catfish (*clarias gariepinus*). The Fungi count of the fresh ginger treated samples ranged from mean log 1.65 to 2.28 Cfu/g while the control is 2.76 Cfu/g. In addition the ginger treated smoked samples ranged from 0.70 to 1.35 Cfu/g on Day 0 as against the 2.30 Cfu/g of the control. The result indicated that the higher the concentration of ginger showed the higher the antifungal effects. Catfish treated with both 7.5% and 10% ginger solution had no noticeable mould growth after four weeks of storage. Alcohol extracts of ginger also showed antifungal activity in vitro on Penicillium digitatum, Aspergillus Niger and *Fusarium* sp on isolated from naturally infected citrus fruit. Penicillium digitatum exhibited a reduction in a colony development ranging from an average of 52%, 69%, 74 % and 83 % at concentration of 500, 1000, 2000, and 3000ppm respectively. Aspergillus Niger recorded inhibition zones of 56%, 73%, 78% and 91 % at similar plant extract concentrations respectively. The inhibition zones observed in Fusarium sp were 49%, 61%, 69% and 88% respectively [15].

Alcohol extract chilly found 100 % inhibition zones on Penicillium digitatum, Aspergillus Niger and Fusarium sp at concentration of 3000 ppm [15]

[17] Studied the inhibitory property of aqueous extracts of rhizomes of ginger (Zingiber Officinale) and leaves of eucalyptus saligna and polyalthia longifolia on *candida albicans*. The researcher concluded that the aqueous extracts of these plants offer potential antifungal property against *candida albicans*, with eucalyptus saligna offering the highest antifungal activity (19mm inhibition zone). The minimum inhibitory concentration of the extracts ranged from 0.05 mg/ml to 30 mg/ml.

[16] studied the inhibitory property of nigella sativa active components (thymoquinone and amphotericine B) on Aspergillus Niger and thymoquinone contain in at concentration of 0.062, 0.125, 0.25, 0.5, 1.0 & 2.0 mg/ml showed 16.7, 36.2, 47.3, 67.8, 90.6 & 100% inhibition of growth of Aspergillus niger with these concentrations after 96 hours of incubation. Similarly there were 52.3, 65.1, 76.7, 81.6, 84.7, 85.6, 90.7, 92 and 93.8% inhibition of growth with 0.007, 0.015, 0.031, 0.062, 0.125, 0.25, 0.5, 1.0 and 2.0mg/ml of amphotericin B.

Cinnamaldehyde is an aromatic α, β- unsatured aldehyde, and the key component in essential oils from cinnamon species. It has been antimicrobial activity against a wide range of micro organism including bacteria, yeasts, and molds. Gliadin films incorporating cinnamaldehyde were highly effective against fungal growth. P.*expansum* and A.*niger* were completely inhibited after storage in vitro for 10 days in the presence of films incorporating 3% cinnamaldehyde. Active food packaging with gliadin films incorporating 5% cinnamaldehyde increased the shelf-life of both sliced bread and cheese spread foodstuffs. [18]

The essential oils of spices and herbs showed notable antifungal inhibition zones against fungal strains of tested microorganisms (Aspergillus oryzae, Fusarium culmorum, Fusarium graminearum, Aspergillus brasiliensis and Aspergillus flavus) (table Clove bud oil and oregano oil offered the most successful antifungal activity in direct contact method

Against all the fungal strains tested [13] (Table1)

Source: [13].*the diameter of the filter paper disc (6 mm) is included. No inhibition (< 6 mm diameter) ; A.o – *Aspergillus oryzae*, A. f – *Aspergillus flavus*, A. b – *Aspergillus brasiliensis*, F.c – *Fusarium culmorum*, F. g – *Fusarium graminearum*

Antibacterial Activities of Spices and Herbs

Antibacterial activity of spice has been noted on bacteria and

Table 1. Antifungal activity of the tested essential oils by direct contact method.

Essential oils	Mean inhibition zone diameter (mm)*after 120 h of incubation				
	A. o	A. f	A. b	F. c	F. g
White thyme	24.6 ± 0.15	12	15.6 ± 0.11	24.3 ± 0.05	-
Clove bud	48 ± 0.26	28.6 ± 0.05	32 ± 0.17	30 ± 0.25	40.6 ± 0.37
Oregano	57.6 ± 0.05	31.6 ± 0.45	34 ± 0.1	49.6 ± 0.64	-
Cinnamon leaf	39.3 ± 0.15	28 ± 0.17	25.6 ± 0.05	16 ± 0.1	34.6 ± 0.32
Onion	-	17.5 ± 0.35	-	6.0	-
Garlic	-	-	-	6.0	-
Basil	9.6 ± 0.11	8.3 ± 0.05	6.0	6.0	6.0

Table 2. Antibacterial activity of *Perinari excelsa* seed extract at different concentrations.

Isolates	Ciprofloxacin (control) 10mg/ml	Zones of Inhibition in mm at different concentration (mg/ml)							
		30mg/ml		20mg/ml		10mg/ml		5mg/ml	
		Aqueous	Ethanol	Aqueous	Ethanol	Aqueous	Ethanol	Aqueous	Ethanol
S. aureus	24.50	12.42 ±0.16	22.38 ± 0.48	9.44 ± 0.18	16.63 ± 0.10	7.33 ± 0.42	13.65 ± 0.13	4.10 ± 0.13	8.60 ± 0.15
E.coli	23.00	9.60 ± 0.25	15.28 ± 0.45	7.25 ± 0.48	11.45 ± 0.64	4.38 ± 0.19	6.30 ± 0.36	1.43 ± 0.31	2.28 ± 0.18
K.pneumonia	25.00	11.43 ± 0.08	16.77 ± 0.31	7.43 ± 0.40	12.37 ± 0.25	3.83 ± 0.25	5.77 ± 0.45	2.17 ± 0.40	3.47 ± 0.25
S. typhi	24.50	10.50 ± 0.20	15.55 ± 0.13	8.07 ± 0.25	11.93 ± 0.42	4.20 ± 0.20	6.50 ± 0.50	2.40 ± 0.26	3.40 ± 0.20

pathogenic and/or spoiling yeasts, additionally on the production of toxic microbial metabolites.[7] studied the shelf life of bread with added turmeric powder, turmeric essential oil and turmeric extracted residue at 0.10% by storing for 7 days and noted that turmeric residue adding bread can be stored for 4 days at room temperature and 5 days at 25°C follow standard community of bread had total plate count no more $1x10^4$ colony/sample. It had showed strong antimicrobial activities as compared to the control sample.

[8] Assayed the effects of Aframomum danielli and Zingiber offcinale crude extract on the storability of fried bean cake snacks. The fried bean cakes were spiced with 0.2, 0.4, 0.6, 0.8 and 1% of both spices. The analysis showed that A. Danielli and *Z. ofcinale* had inhibitory effect on the bacterial (total viable counts) fried bean cake samples. The antibacterial effect increased with increase in the concentration of the spice extract.

[20] Evaluating the comparative antibacterial effect of ginger (*Zingiber officinale*) extract (water and ethanol) from root and plant leaves and some antibiotics (chloramphenicol, ampicillin and tetracycline) on staphylococcus aureus and streptococcus pyogenes. The result showed that ginger extract of both the leaf and root showed the highest antibacterial activity against staphylococcus aureus and streptococcus pyogenes while the three antibiotics used. The data from this experiment also showed that ethanol extract were more successful than the water extract.

[19] Studied the antimicrobial effectiveness of n-hexane, ethyl acetate, ethanolic soxhlet and water extracts from ginger roots (1.0%, 0.5%, 0.25%, and 0.125%) on the bacteria of coliform *bacillus*, staphylococcus epidermidis and streptococcus viridians. The researchers noted that excepting the water extract have antibacterial activities. The results that ginger roots extracts, viz. n-hexane, ethyl acetate and soxhlet extracts have antibacterial activities on colliform bacillus, staphylococcus epidermidis and streptococcus viridians while the water extract did not showed antibacterial activity on the selected bacteria's. The result indicated that bacteria's growth inhibition are active at high concentration (1.0 and 0.5%) of extracts and inactive at very low concentrations (0.25%, and 0.125%). Hence ethanolic extracts of ginger also had antibacterial activity against staphylococcus aureus and pseudomonas aeruginosa. The antibacterial activity and inhibition activity of ginger extracts could be accredited to the chemical properties of ginger (sesquiterpenoids, zingiberene, trace monoterpenoid fractions).

Ginger extract at 5% concentration also inhibited the growth of *vibrio* parahaemolyticus, *Bacillus cereus*, Proteus mirabilis and Pseudomonas aeruginosa [31]

Oregano bread had a shelf life of 6 days at room temperature. This may be due to incorporation of oregano obviously increased the total phenol content and the radical scavenging activity of bread. Oregano bread had an increase of phenolics amount of around three-time compared to the quantity contained in the control (0% oregano) [9]

The essential oil of oregano, clove bud and white thyme oil exhibited the most useful antibacterial activity in direct contact method specifically against E. *coli* and *B. cereus*, with inhibition zones of 42 mm, 31.2 mm and 39.3 mm for *E. coli, and* 45.2 mm, 28 mm and 35.5 for B. *cereus* respectively, having a bigger inhibition diameter than the control sample (streptomycin 50 mg/ml). These activity might be strictly associated to their chemical components: in fact, carvacrol, thymol and eugenol found in these oils, work on the cell membrane increasing its permeability [13] The antibacterial effect of seed extract of *Perinari excelsa* was tested against four clinical isolates namely S. *aureus*, E.*coli*, K. pneumonia, and S. typhi at different concentration and the result showed (table 2) that the seed extract is helpful though at varying degrees to all the tested organisms. Both aqueous and ethanolic extracts were the most successful against S. *aureus* [21]

(Table 2)

Source: [21]. :

Essential oils and/or their components are becoming progressively more popular as natural antimicrobial agents to be used for a wide variety of purposes, including food preservation, complementary medicine and natural therapeutics. Essential oils extracted from oregano, sage, mint and laurel showed antimicrobial activity against 14 strains of bacteria (table 3) and the diameters of growth inhibition zone ranged from 7 mm to 22 mm for test bacteria (including the diameter of the disc-6 mm). The results of antimicrobial assay showed that the most useful essential oil was extracted from *Origanum onites* L. then next *Laurus nobilus* L., Mentha piperita L. and Salvia triloba L., respectively. Twenty (20 µl) oil extracts applicable in all experiments showed inhibition effect against E. *coli* and S. typhimurium. Application of at least 15 µl Origanum onites L had an effect on S. thermophilus ST36, it was seen that only extraction of Origanum onites L. Oil had an effect on L. rhamnosus CSL. As well, it was observed that the quantity of oil had an encouraging effect on inhibition levels; *Origanum onites* L oil can be a good source of antimicrobial agents in some food products for bio preservation and medical applications [23].

[24] Assaying the antimicrobial effect of ginger spices (*Zingiber officinale*) on the cookies (biscuit) produced from blends of melon flour 'egusi' (*Critrullus coloynthis* l) and wheat flour (*Triticum spp*). The researcher observed that the ginger possesses antimicrobial properties on mean total viable count, *Bacillus*, *coliform*, *Staphylococcus* and fungi count. The result

Reveals that the increase in ginger concentration leads to noticeable decrease (reduction) in microbial load

[25] Assayed the inhibitory action of black cumin (*nigella sativa* L.) seed extracts were obtained using supercritical carbon dioxide (SCCO2) and conventional soxtec extraction on various bacteria (*Bacillus cereus* F 4810, *Staphylococcus aureus* FRI 722, Escherichia coli MTCC 108 and *Yersinia* enterocolitica MTCC 859). All the tested extracts were found to be active against Gram-positive than Gram-negative bacteria. Thymoquinone, an energetic constituent of nigella sativa seeds, is a pharmacologically active quinone, which possesses several pharmacological properties including analgesic and anti-inflammatory actions [22]

(Table3)Source: [23]; where: S, sage (*Salvia triloba* L.); M, mint (*Mentha piperita* L.); L, laurel (*Laurus nobilus* L.); O, oregano (*Origanum onites* L.).

Antioxidant Effects of Spices and Herbs

A great number of publications have reported the antioxidant capability of spices and their extracts in vitro. Antioxidants are useful in health and lowering the risk for cancer, hypertension

Table 3. Antimicrobial activity of essential oils extracted from various plants (mm).

Indicator strain	S (5 µL)	S (10 µL)	S (15 µL)	S (20 µL)	M (5 µL)	M (10 µL)	M (15 µL)	M (20 µL)	L (5 µL)	L (10 µL)	L (15 µL)	L (20 µL)	O (5 µL)	O (10 µL)	O (15 µL)	O (20 µL)
Listeria monocytogenes ATCC 7644	-	-	-	7	-	-	-	-	-	-	8	9	-	8	8	9
Escherichia coli O157:H7 ATCC 8739	9	12	13	15	-	12	12	14	14	18	18	19	-	9	10	10
Salmonellatyphimurium ATCC 14028	9	10	11	12	16	18	19	20	8	10	11	12	20	21	22	23
Staphylococcus aureus ATCC 25923	-	-	7	7	-	-	-	-	-	9	10	10	10	12	12	13
Enterococcus faecalis ATCC 29212	-	-	-	-	-	-	-	7	-	-	8	8	-	-	8	8
Enterococcus faecium B-2354	-	-	-	-	-	-	-	8	-	-	-	8	-	8	8	9
Enterococcus casseliflavus B- 3502	-	-	-	-	-	-	-	-	-	-	8	8	-	7	9	12
Streptococcus thermophilus ST36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	10
Lactobacillus casei B-1922	-	-	-	-	-	-	-	-	-	-	-	-	7	8	10	12
Lactobacillus casei B26	-	-	-	-	-	-	-	-	-	--	-	-	9	13	10	11
Lactobacillus rhamnosus B-442	-	-	7	8	-	-	-	-	-	-	-	7	7	8	8	11
Lactobacillus rhamnosus CSL	-	-	-	-	-	-	-	-	-	-	-	-	7	7	9	10
Lactobacillus plantarumB-4496	-	-	-	-	-	-	-	8					13	14	14	16
Lactobaillus plantarum CSL							7	8					7	8	11	13

and heart disease. The naturally occurring antioxidants of therapeutic plants such as polyphenols (phenolic diterpenes, diphenolic diterpenes) and flavonoids show a high capability to donate hydrogen from phenolic hydroxyl groups, thereby forming stable free radicals [27]. Spices and herbs are an excellent source of phenolic compounds (favonoids, phenolic acid and alcohols, stilbenes, tocopherols, tocotrienols), ascorbic acid and carotenoids which have been reported to exhibit good antioxidant activity [28].

[28] Assaying the antioxidant activity ((DPPH radical scavenging assay and FRAP ferric-reducing antioxidant power assay) of kesum (*Polygonum minus*), ginger (*Zingiber offcinale*) and turmeric (*Curcuma longa*) extract (without solvent) and the result showed that kesum, ginger and turmeric had good antioxidant activity. A significant and linear relationship existed between the antioxidant activity and phenolic content of kesum, ginger and turmeric, thus indicating that phenolic compounds are major contributors to antioxidant activity (table 4).

[26] studied antioxidant potential of black cumin seed (fixed and essential oil). Antioxidant activity based on coupled oxidation of β-carotene and linoleic acid was determined; black cumin fixed and essential oils inhibited lipid peroxidation by 25.62 and 92.56%, respectively. afterward, DPPH assay was also conducted that is another section to study the antioxidant potential of test materials; black cumin fixed and essential oils repressed DPPH radical formation by 32.32 and 80.25%, respectively. Because of the simplicity and expediency, DPPH assay has an ordinary use in free radical scavenging assessment [29]; [30]. Numerous spices have high levels of phenolics compounds and confirmed high antioxidant capacity (table 4). (Table 4)

Source:[28] A greatly positive linear relationship (R^2=0.95) obtained between Total equivalent antioxidant capacity values and total phenolic content showed that phenolic compounds in the tested spices (26 common spice) contributed significantly to their antioxidant capacity [1] . (Table5)

Ginger has lowered the free fatty acid (FFA) values, trimethylamine (TMA) values in the processed fish [12]

Source: [1]

Nutritional effects of spices and herbs

[26] Studied nutritional profile of indigenous cultivar of black cumin seed. Compositional analysis showed that it contains noticeable quantities of carbohydrates, proteins and fats. In addition, potassium, calcium, phosphorous and magnesium were major minerals, even as considerable quantities of sodium, iron, manganese, zinc and copper were also present. Black cumin seeds contain 6.46±0.17, 22.80±0.60, 31.16±0.82,

Table 4. Total phenolic content, DPPH inhibition and ferric reducing/antioxidant power assay of spices and herb extracts.

Spices and herb extracts	Total phenolic (mg GAE/100g extracts)	DPPH inhibition (%)	FRAP (µmol Fe (II)/ g extracts
Polygonum minus	165.3 ± 1.0^{a}	82.6 ± 0.7^{a}	46.3 ± 1.2^{a}
Zingiber offcinale	101.6 ± 0.6^{d}	79.0 ± 0.6^{b}	26.2 ± 0.0^{cd}
Curcuma longa	67.9 ± 1.0^{f}	64.6 ± 2.4^{e}	23.3 ± 0.9^{e}
Polygonum minus: Zingiber offcinale (1:1)	132.0 ± 1.9^{b}	79.4 ± 1.2^{b}	34.4 ± 1.1^{b}
Polygonum minus: Curcuma longa (1:1)	103.3 ± 1.1^{cd}	73.4 ± 2.7^{c}	27.5 ± 0.7^{c}
Zingiber offcinale : Curcuma longa (1:1	73.6 ± 1.2^{e}	68.6 ± 1.8^{d}	25.3 ± 0.7^{d}
Polygonum minus: Zingiber offcinale : Curcuma longa (1:1:1)	104.7 ± 1.2^{c}	78.1 ± 0.8^{b}	23.1 ± 0.2^{e}

Table 5. Antioxidant Capacity, Total Phenolic Content, and major phenolic Compounds of Methanolic Extracts from 26 Spices[a].

Family and scientific name	common name	country/place	ed-ible parts tested	Total equivalent antioxidant capacity (mmol of trolo x/ 100 g of DW) [b]	Total phenolic content (g of GAE/ 100 g of DW) [c]	Major type (representative components) of phenolic com-pounds
Gramineae						
Cymbopogon citrates Stapf.	lemon grass	Hong Kong	stem	4.41 ± 0.003	0.25 ± 0.009	phenolic acids, volatile oils, flavonoids
Illiciaceae						
Illicium verum Hook. f.	star anise	China	fruit	20.30 ± 0.008	2.02 ± 0.014	phenolic acids (protocatechuic acid), phenolic volatile oils (anethole),flavonoids
Labiatae						
Mentha canadensis L	mint	Hong Kong	leaf and branch	33.83 ± 0.016	5.15 ± 0.025	phenolic acids (caffeic acid, rosmarinicacid), Volatile compounds (menthol), flavonoids
Ocimum basilicum L.	sweet basil	New Zealand	leaf	29.59 ± 0.004	3.64 ± 0.014	phenolic acids (rosmarinic acid, caffeoyl de-rivatives), phenolic diterpenes, Volatile compounds (carvacrol), flavonoids (catechin)
Origanum vulgare L.	oregano	New Zealand	leaf	100.67 ± 0.009	10.17 ± 0.010	phenolic acids (caffeic acid, p-coumaric acid, rosmarinic acid, caffeoyl derivatives), volatile compounds (carvacrol), flavonoids
Rosmarinus officinalis L.	rosemar y	New Zealan d	leaf an d branch	37.80 ± 0.021	5.07 ± 0.036	phenolic acids (caffeic acid, rosmarinic acid, caffeoyl derivatives), phenolic diterpenes (carnosic acid, carnoso l, epirosmanol), volatile compounds (carvacrol), flavonoids
Salvia officinalis L.	sage	New Zealan d	leaf an d branch	51.89 ± 0.006	5.32 ± 0.006	phenolic acids (rosmarinic acid), phenolic diterpenes (carnosic acid), volatile compounds, flavonoids
Thymus vulgaris L.	thyme	New Zealan d	leaf an d branch	38.07 ± 0.003	4.52 ± 0.006	phenolic acids (gallic acid, caffeic aci d, rosmarinic acid), volatile compounds (thymol), phenolic
Lauraceae						
Laurus nobilis L.	bay	U.S.A.	leaf	34.29 ± 0.001	4.17 ± 0.005	phenolic acids, volatile oils (cinnamic derivatives), flavonoids
Cinnamomum cassia Presl	cinnamo n	China	cortex/ bark	61.75 ± 0.014	6.34 ± 0.021	phenolic acids, phenolic volatile oils (2hydroxycinnamaldehyde, cinnamyl aldehyde derivatives), flavan-3-ols

Family and scientific name	common name	country/place	edible parts tested	Total equivalent antioidant capacity (mmol of trolo x/ 100 g of DW) [b]	Total phenolic content (g of GAE/ 100 g of DW) [c]	Major type (representative components) of phenolic compounds
Cinnamomum zeylanium N.	cinnamon stick	Indonesia	cortex/ bark	107.69 ± 0.010	11.90 ± 0.004	phenolic acids, phenolic volatile oils (2hydroxycinnamaldehyde, cinnamyl aldehyde derivatives), flavan-3-ols
Myristicaceae						
Myristica fragrans Houtt.	nutmeg	East/West Indies	fruit	20.01 ± 0.017	1.61 ± 0.001	phenolic volatile oils, phenolic acid (caffeic acid),flavanols (catechin)
Myrtaceae						
Eugenia caryophylata Thunb.	clove	Malaysia	bud	168.66 ± 0.02 4	14.38 ± 0.006	phenolic acids (gallic acid),flavonol glucosides, phenolic volatile oils (eugenol, acetyl eugenol), tannins
Papaveraceae						
Papaver somniferum L.	poppy	Dutch	seed	0.55 ± 0.002	0.04 ± 0.004	not identified
Piperaceae						
Piper nigrum L.	green peppercorn	U.S.A.	fruit	11.15 ± 0.007	0.38 ± 0.003	volatile oils, phenolic amides
Piper nigrum L.	black pepper	U.S.A.	fruit	4.56 ± 0.013	0.30 ± 0.002	volatile oils, phenolic amides
Piper nigrum L.	white pepper	France	fruit	8.97 ± 0.007	0.78 ± 0.004	volatile oils, phenolic amides
Solanaceae						
Capsicum annuum L.	chilli	Thailand	fruit	6.05 ± 0.003	0.86 ± 0.004	volatile oils, phenolic acids
Umbelliferae						
Carum carvi L.	caraway	U.S.A.	fruit	5.50 ± 0.008	0.61 ± 0.017	volatile oils, phenolic acids, flavonoids(kaempferol), coumarins
Coriandrum sativum L.	coriander	Hong Kong	whole plant	7.02 ± 0.004	0.88 ± 0.007	phenolic acids (caffeic acid), flavonoids, volatile oil
Cuminum cyminum L.	cumin	Turkey	fruit	6.61 ± 0.002	0.23 ± 0.005	volatile oils, phenolic acids, flavonoids (kaempferol), coumarins
Zingiberaceae						
Zingiber	ginger	China	rhizome	7.89 ± 0.009	0.63 ± 0.009	phenolic volatile oils (gingerol, shogaol),
Amomum subulatum Roxb	green cardamom	U.S.A.	fruit	7.53 ± 0.004	0.46 ± 0.009	phenolic acids (caffeic acid), volatile oils

6.03±0.16 and 4.20±0.11% of moisture, proteins, fat, fiber, ash contents, respectively, while nitrogen free extract was found to be 29.36±0.78%. Mineral composition showed that potassium is leading (808.00±6.61 mg/100g) subsequently calcium (570±21.5 mg/100g), phosphorous (543±10.04 mg/100g) and magnesium (265±4.87 mg/100g), respectively. Furthermore, significant quantities of sodium, iron, manganese, zinc and copper were found in the native variety of black cumin seeds. Fatty acid report of black cumin fixed oil shows that linoleic, oleic and palmitic acids were the main fractions amounting 57.38±1.53, 19.65±0.61 and 12.07±0.87%, respectively. Myristoleic, stearic, eicosenoic and dihomolionolenic acids were present in quantities of 2.49±0.03, 2.35±0.04, and 1.47±0.05 and 1.80±0.11% of the fixed oil, respectively. Black cumin essential oil was evaluated for its dynamic ingredients through GC-MS; showed that it contains thymoquionone, dihydrothmoqionone, p-cymene, carvacrol, α-thujene, thymol, α-pinene, β-pinene and t-anethole as key constituents i.e., 23.25±1.03, 3.84±0.12, 32.02±1.01, 10.38±0.30, 2.40±0.06, 2.32±0.26, 1.48±0.02, 1.72±0.05 and 2.10±0.42%, respectively.

Oregano found to be rich in crude fibre (17.43%), total phenol content (87.80 GAE/100g DW) and antioxidant activity (84.80%) which supports its use as a functional food [9]. The essential oil from oregano contain mainly of carvacrol (65.49%), linalool (12.54%), thujon (11.05%), γ- terpinene (1.70%) and borneol (1.59%) [23]. (Table 6)

In mint essential oil, 13 compounds were identified (table 6). The main components were menthol, menthone, menthofuran, 1-8

Table 6. Chemical composition of essentials oil (%).

Chemical component	Oregano (*Origanum onites* L.)	Mint (*Mentha piperita* L.)	Sage (*Salvia triloba* L.)	Laurel (*Laurus nobilus* L.)
α-Pinen	0.14	0.37	3.91	5.77
ß-Pinen	0.07	0.12	3.25	0.76
Myrecene	0.38	0.14	3.50	-
α -Humulene	-	0.859	1.30	0.12
transcaryophylene	-	1.71	5.22	3.06
γ-Terpinen	1.70	0.11	1.17	0.15
Menthofuran	0.11	6.13	-	-
Carvon	0.37	10.61	-	0.42
Pulegon	0.30	2.12	-	-
Menthone	0.13	20.15	-	-
Thujon	1.05	-	30.55	-
Borneol	1.59	0.06	5.01	-
Carvacrol	65.49	-	2.44	0.25
1-8-cineole	-	5.59	11.45	44.97
Menthol	0.07	35.12	-	-
Linalool	12.54	-	-	9.22
Camphor	1.00	1.50	20.33	1.20
Thymol	2.75	-	1.11	0.15

Table 7. Additional functions of common spices.

Spices	Uses	Reference
Ginger (Zingiber officinale)	Antioxidants, Anti-inflammatory properties, antiemetic effect, antibacterial and antifungal activity	(L. Tchombé N.*, 2012), (Hala, 2011)
Coriander (Coriandrum sativum)	Antioxidants	(Deepa, G., Ayesha, S., Nishtha, K. and Thankamani, 2013)
mustard	antifungal	(Azzouz & Bullerman, 1982)
Clove (Syzygium aromaticum)	Antimicrobial activity, antifungal, Antioxidant	(Sethi, Dutta, Gupta, & Gupta, 2013), (Lu, L, & Alemdar, 2007), Azzouz & Bullerman, 1982,(Hala, 2011) , (Girova et al., 2010), (Tayel & El-tras, 2009)
Cumin (Cuminum cyminum)	Antimicrobial activity, Antioxidant	Sethi, Dutta, Gupta, & Gupta, 2013, (Lu, L, & Alemdar, 2007,(Jime, Strabbioli, & Murcia, 2001) ;Hala, 2011
Garlic (Allium Sativum)	Antifungal, Antioxidant, antimicrobial	Azzouz & Bullerman, 1982; Hala, 2011; Bedia et al, 2005
Saffron (Crocus sativus)	Antimicrobial activity, Antioxidant	Sethi et al., 2013; (ime et al., 2001
Cinnamon (Cinnamomum Verum)	Antifungal, antimicrobial and antioxidant	Azzouz & Bullerman, 1982; Lu, L, & Alemdar, 2007; Tayel & El-tras, 2009; Noorolah Z, Sahari MA, Barzegar M, Doraki N, 2013
Oregano (Origanum vulgare L)	Antifungal, Antioxidant, antimicrobial	Azzouz & Bullerman, 1982; Jime, Strabbioli, & Murcia, 2001; Girova et al., 2010; Tayel & El-tras, 2009; Passos, Dora, & Melo, 2012
Rosemary (Rosmarinus officinalis)	Antioxidant, antimicrobial	Jime, Strabbioli, & Murcia, 2001 ;Tayel & El-tras, 2009
Coriander (Coriandrum sativum)	Antioxidant	Hala, 2011
thyme (Thymus vulgaris, L)	antimicrobial	Hala, 2011; Girova et al., 2010; Tayel & El-tras, 2009; Simsek, Sagdic, & Ozcelik, 2007

cineole, pulegan, Tran's coryophyllene. Several studies reported that the essential oil component of mint is menthol, menthone, carvone, menthofuran, 1-8 cineoles [23].

Adding 0.5% fennel seeds with 0.5% oregano leaves as feed additives to rabbit diets contained 2% oil improved daily gain; both nutrient digestibility coefficients and nutritive values as well as realized the highest value of relative economic efficiency and lowered value of feed cost/ kg live body weight [32][33][34][35][36][37][38][39][40][41][42][43][44]

Source: [23]. (Table7)

CONCLUSION

The pleasant flavour and pungency of spices make them essential in the preparation of palatable dishes. Spices and herbs are also very concern both in the industry and in scientific research because of their strong antioxidant, antifungal and antibacterial properties, which exceed many currently, used as natural preservatives. These properties are due to a lot of substances, including some vitamins, favonoids, terpenoids, carotenoids, phenols, minerals, etc. Essential oils and/or their components are becoming progressively more popular as natural antimicrobial agents to be used for a wide variety of purposes, including food preservation.

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